Modifying the Green Roof for Down under: A feasibility assessment of a rooftop urban farm

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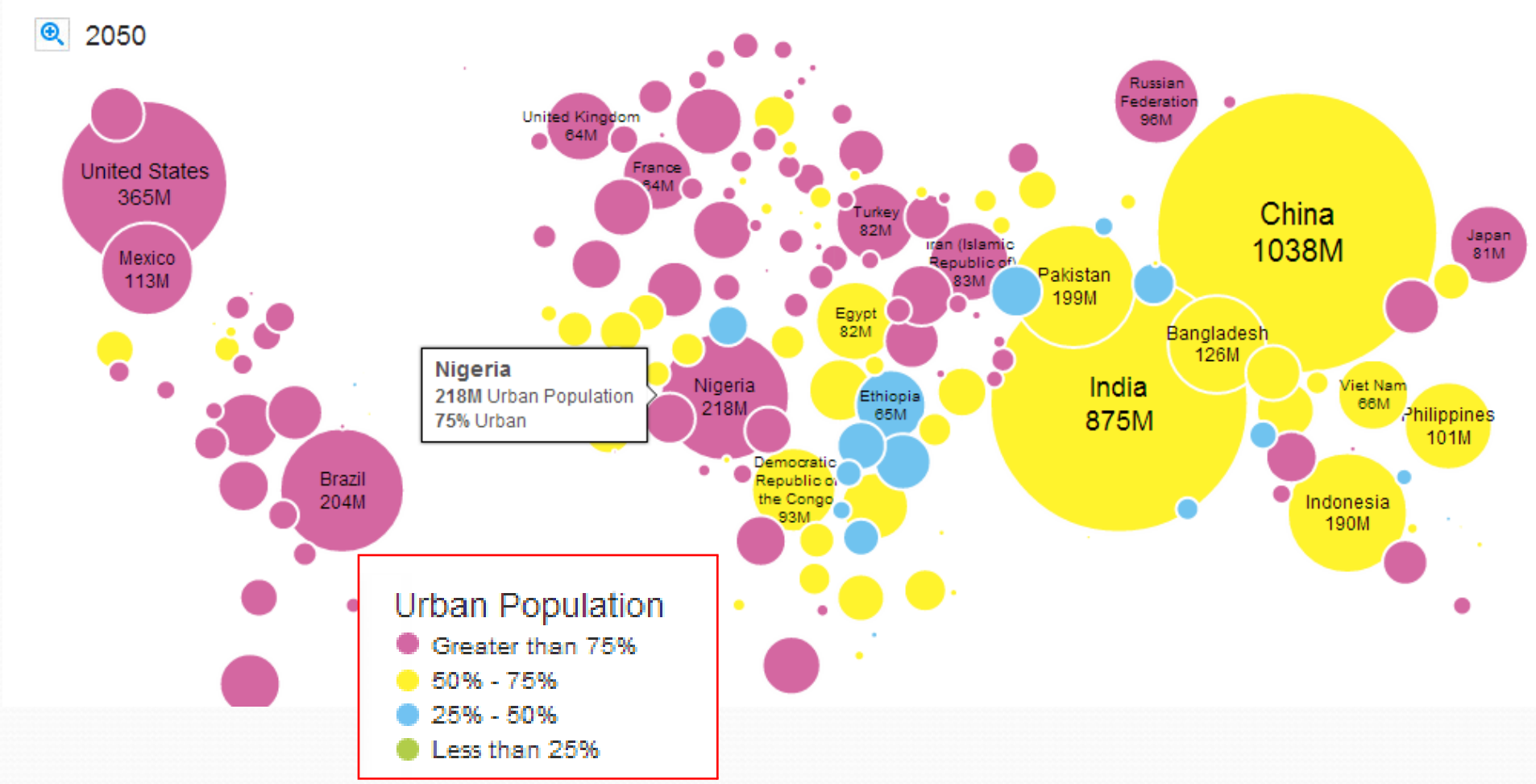
Overview

- Examine the feasibility of modifying the typical European green roof for a dry hot climate
- Our modified green roof takes the form of a commercial urban rooftop farm
- We test our idea on a distribution centre near Sydney by modelling its physical performance & productivity
- and we test its economic feasibility
- Conclusions

The big picture

What is the current context, where are we going and how have things changed over time?

2050 UN population - urban %



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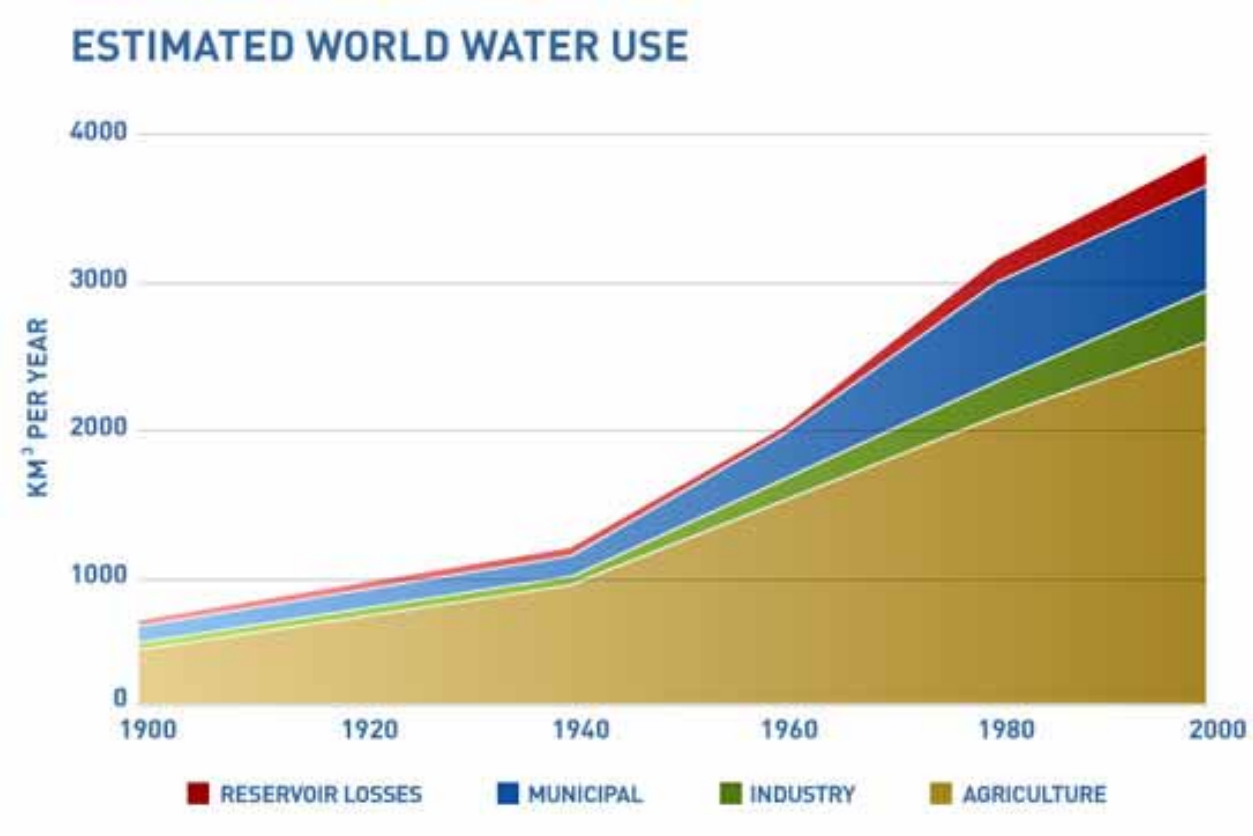
World Demand for Water

Source: Food & Agricultural Organisation

2000 demand: 4,000 km^3 / year

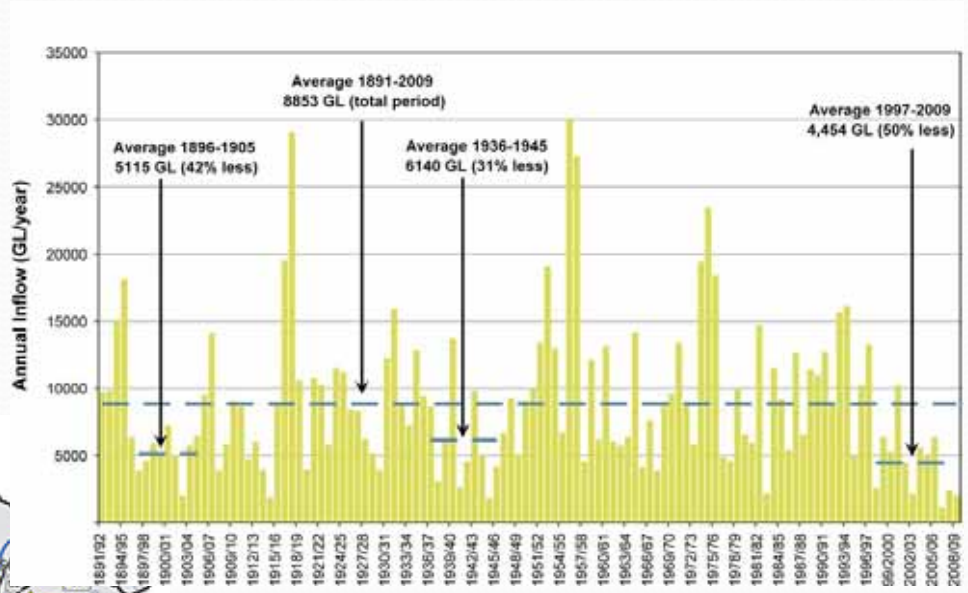
2050 demand: 6,000 km^3 / year

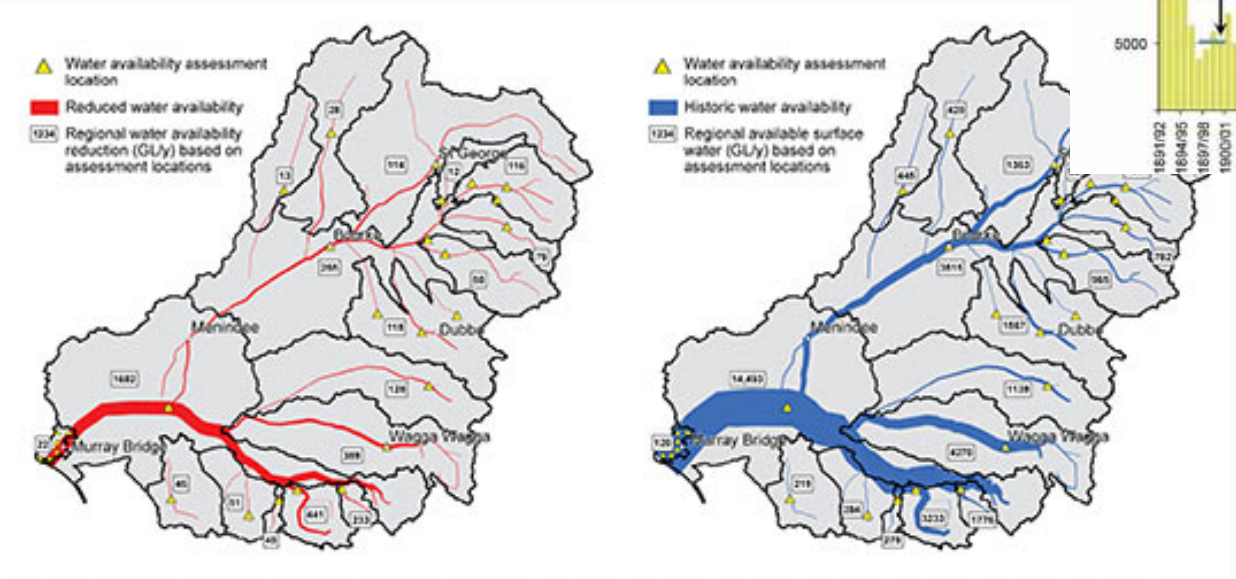
1 km^3 = 1 billion cubic metres



Climate reduced Water Availability

Decline in dry year water availability in the Murray-Darling Basin under a median future climate (2030) compared to the 20th Century Average (right) – CSIRO MDB Sustainable Yields project.





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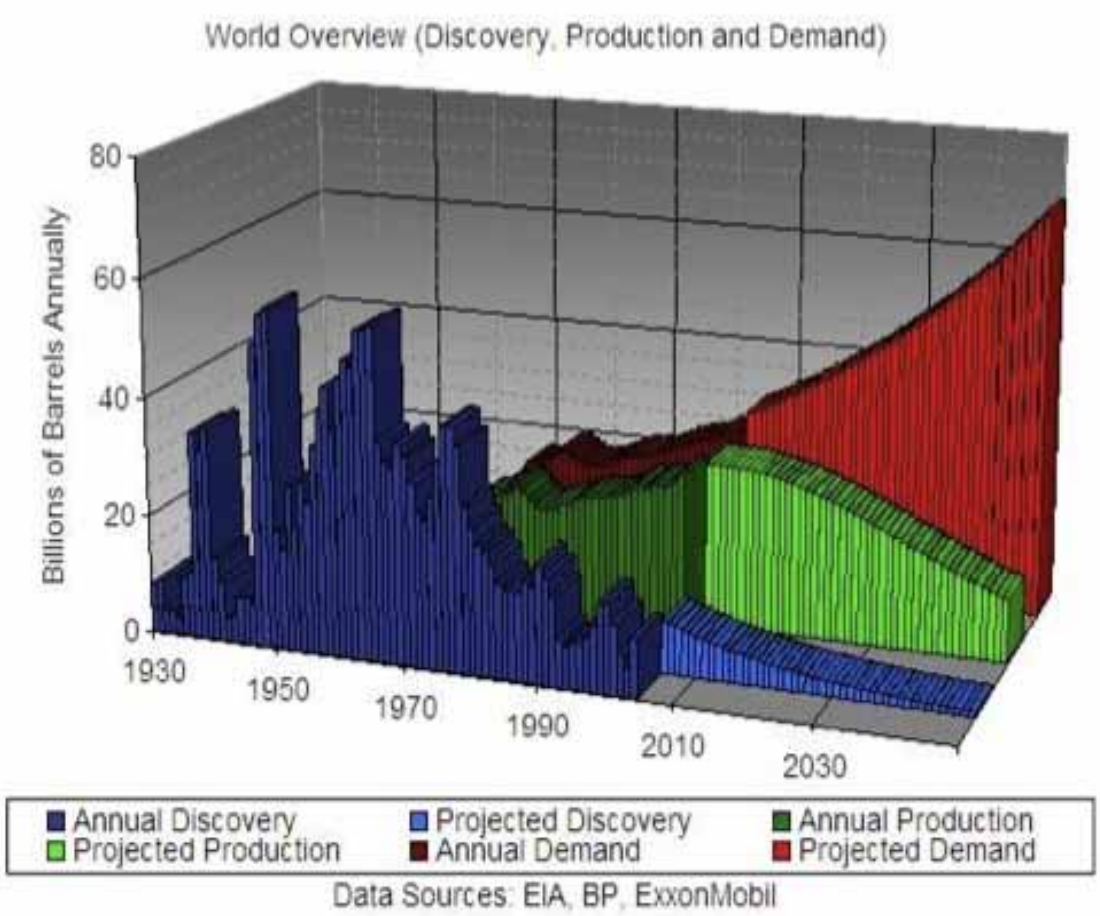
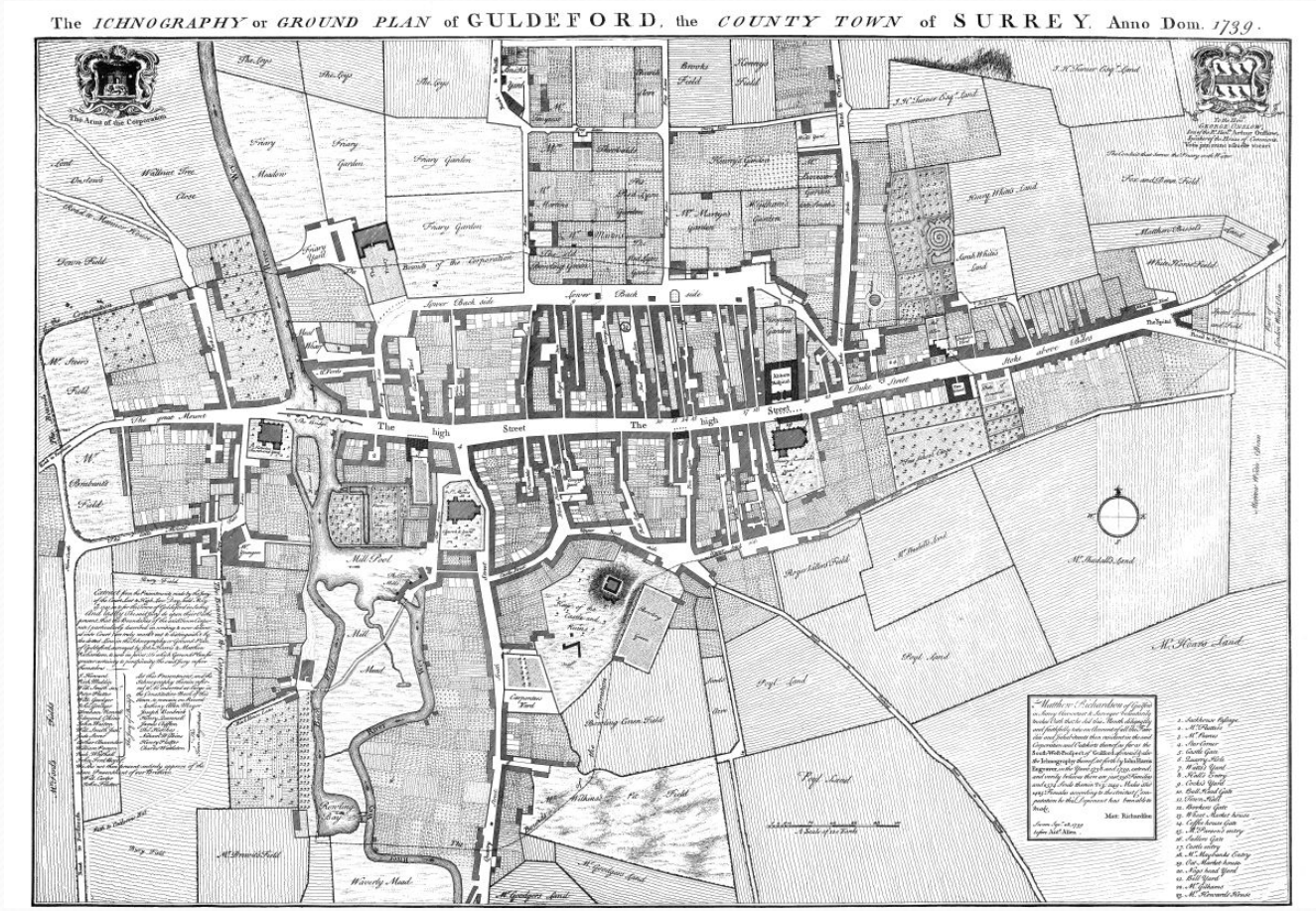
Peak Oil

- Oil production is arguably peaking now!
- From here on the price of oil will increase.
- Brings into question the sustainability of "import from far away" food supply model adopted by most cities.



Source: Transition Towns by Rob Hopkins

Was the past different?



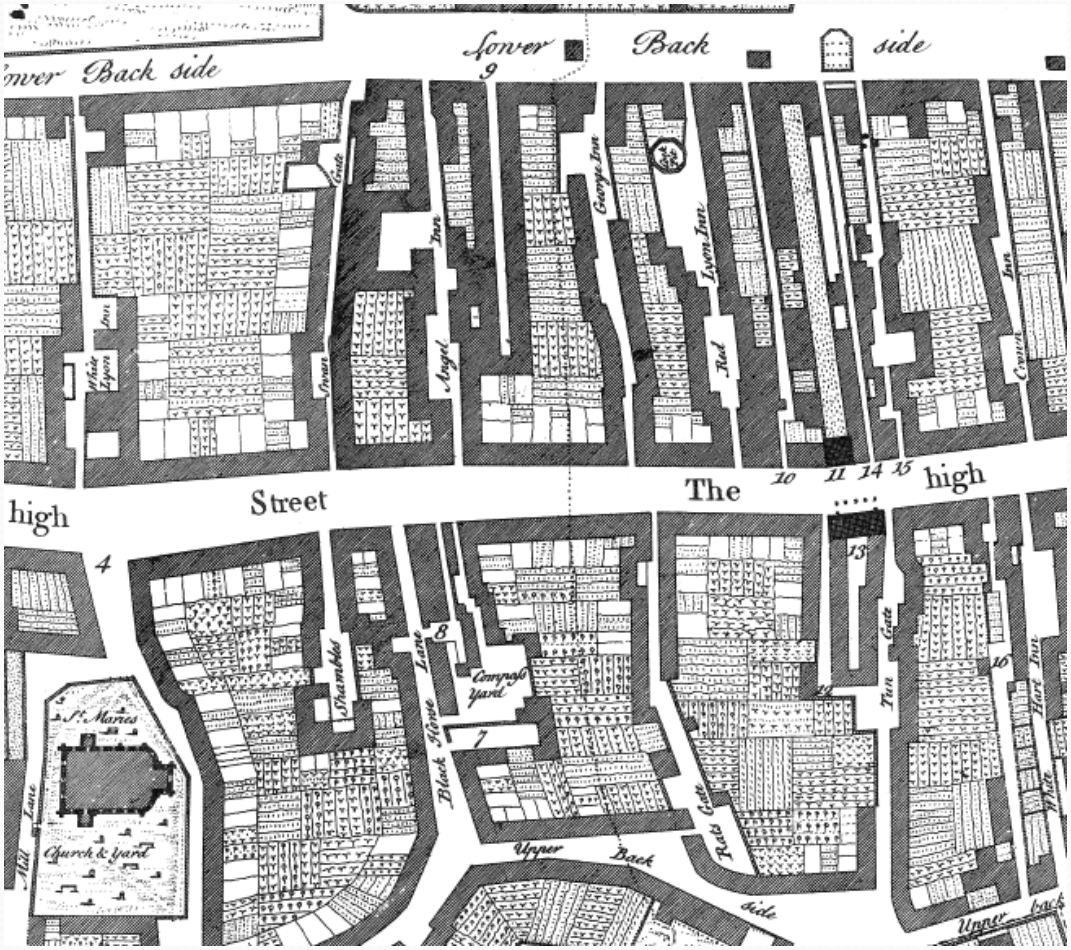
Guildford Surrey in 1739

Is virtually a food map. Food production is most prevalent land use next to buildings and roads

High Street fronted by buildings with almost every other space devoted to food growing.

Source: Transition Town Totnes website.

- 18C Food was grown in every available space. “Food miles” didn’t exist.
- 19C – Cities largely fed from its hinterland.
- 20C – Home & market gardens and peri urban areas made a valuable food contribution esp in WW2.
- 21C – urban land too valuable to farm!



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Modern Day Oz Industrial estates

Yenora – 30 Ha under roof - $370Million value = $1146/$m^2$

1mm runoff = 300 kL
10mm runoff = 3 ML

Prospect Creek is 600m from site.

Intermodel facility with more buildings to come.

Modern Oz Industrial – cont'd

- Erskine Park Industrial Estate 24 Ha Impervious area directly connected to a western Sydney Creek.
- Every m^2 of land is heavily contended

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Impacts & Management of Direct Connection

- Argue, Wright, Wong & Brean, Ladson, Walsh, Fletcher, Central West CMA (STORM_Consulting) & others
- Little Stringy Bark Creek Group working on Residential Areas.
- CWCMA – WSUD Policy - water quantity focus on residential only noting industrial/commercial development is intractable.
- Warnervale – Council & consultants developed a complex centralised approach to pump water around the receiving water to protect it. Grant funding req'd to be viable.

Looking further afield…

Green roofs have been in the European vernacular for thousands of years

European Response

- Green roof and permeable pavers
- Virtually no runoff from site.
- Suitable for wet cool climates such as northern Europe.
- Not suitable for Australia – too dry!

USA response

- Ford Motor Co. Rouge Plant in Michigan
- 4.2 Ha of sedum roof.
- Again not suitable for Oz conditions. Vegetation would dry out.

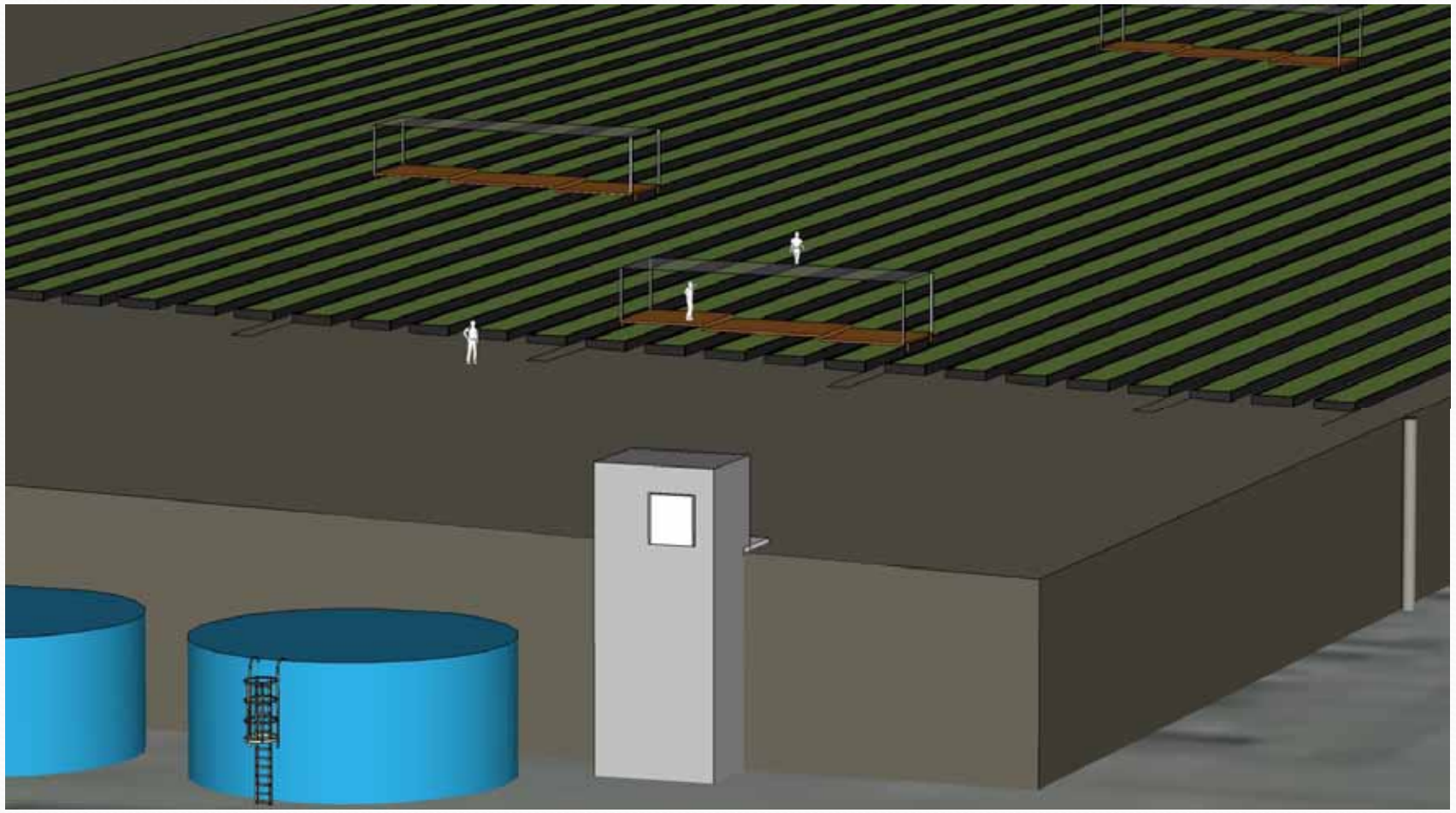
What is suitable for Oz?

- Very hot and dry summers
- Mild winters – sometimes
- Drought 2/3 of the time
- Flood the other third
- Rivers and creeks very sensitive to direct connections
- Food grown in MDB & Tasmania -> high food and water miles.
- Water availability in Basin is reducing.
- Market gardens being driven out of cities.
- CRC for Water Sensitive cities recognises need for productive urban landscapes. This paper tests viability of creating productive landscapes on top of large industrial buildings.

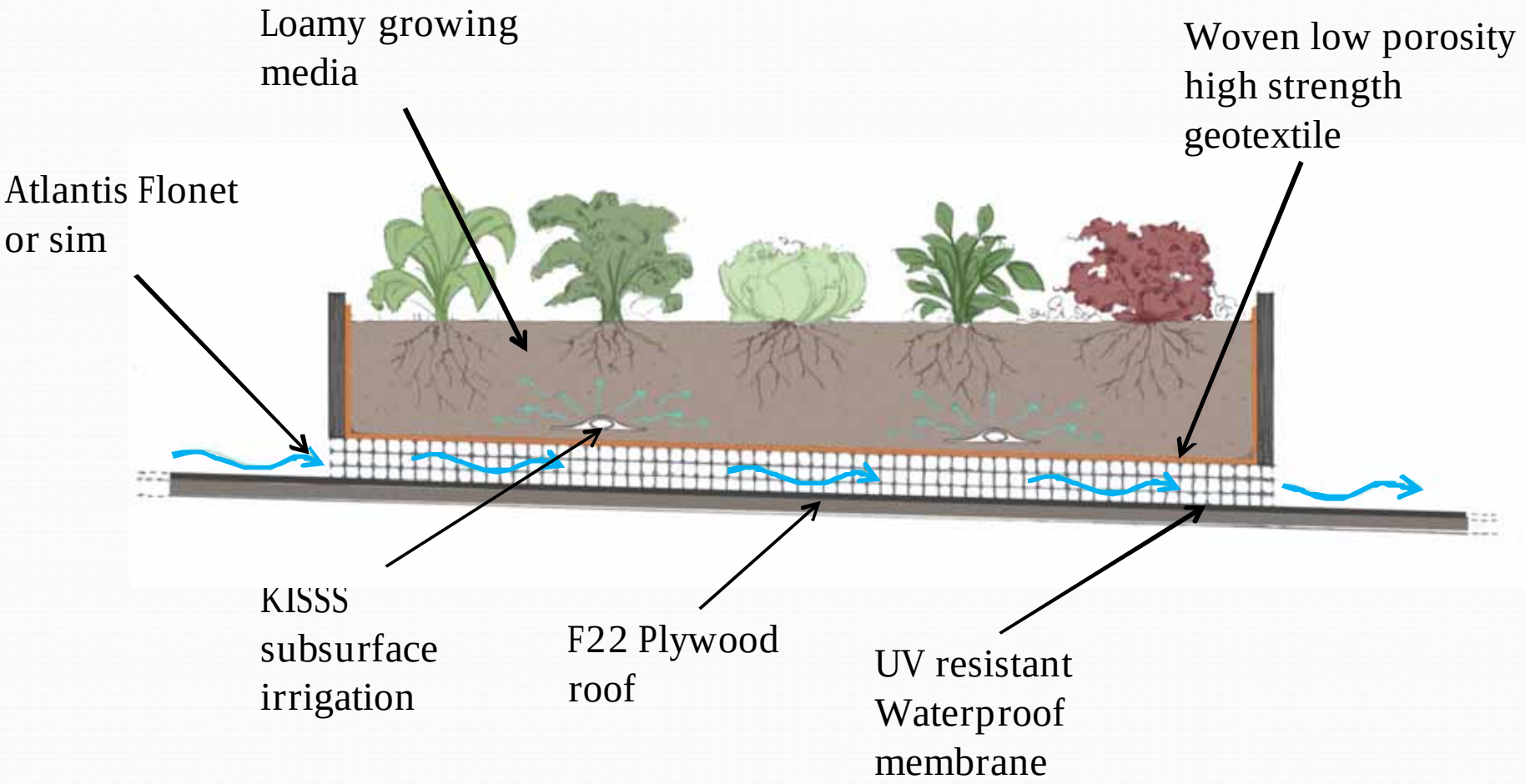
The modified green roof

- 8Ha roof
- 200m wide
- 400m long
- Green roof = 2Ha
- Beds 300m long
- Beds 2m wide
- 1m aisle between
- Rolling platforms
- 6 off 1ML tanks

The modified green roof



The modified green roof



Assessment Methods - Water

- Water balance using MS Excel and MUSIC
- Key facts:
- Rainfall = 867mm/yr at Prospect
- ETo = 1144mm/yr
- Irrigation Demand – Drip irrigation with 85% efficiency
- Demand about 1.1m/yr
- Soil storage 58mm and Field Cap 53mm – 300mm soil depth.
- Tested various scenarios – increasing green roof area in 1 Ha increments – 1 Ha, 2 Ha and 3Ha.
- Method allowed for modelling rainfall + irrigation + ET from beds & roof allowing circular process to be modelled.

Assessment Methods – Structural

- Structural calculations undertaken by Enstruct.
- Retrofit scenario – not viable – loads too high -> too expensive
- New Build – reduced column spacings in both directions
- Larger purlins required – beams remain UB54. Extra columns not significant. Extra over steel = 350 tonnes from extra beams.
- Greenroof constructed-> F22 Plywood + waterproof membrane
- Gantry on 15m span – extra beams required at 15m
- Gantry allowed 500kg loading
- Further optimisation possible – 300 tonne extra possible??

Assessment Methods – Agro-economic

- Detailed construction & operation costs prepared – refer to paper for more details.
- Estimated volume of produce based on ABS farm statistics – likely to be much higher – controlled environment.
- 80 tonnes/annum produce
- Estimated value of produce based 35% of actual retail prices – bagged baby greens retail @ $32/kg - > $11/kg wholesale
- Most baby greens grown in Tasmania - 1600 km to Sydney.
- We allowed for labour, management, bonuses, washing, packaging & delivery etc – ideally supply direct into distribution centre.

Results – raintank water balance

Area of imperv roof (Ha)	Area of Green Roof (Ha)	Flow in (ML/yr)	Flow out (ML/yr)	Runoff frequency (Events/yr)	Reuse requested (ML/yr)	Reuse supplied (ML/yr)	% Reuse Demand Met (%)
8 Ha	No green roof	61	61	149	0.00	0.00	0
7 Ha	1 Ha	60	47	44	11.30	11.30	100
6 Ha	2 Ha	58	35	25	22.60	22.15	98
5 Ha	3 Ha	57	25	21	33.90	30.24	89

Levelised costs of water

$/Yield Calculations			
Interest Rate	4.0%	7.0%	10.0%
Annual Cost	-77,537	-107,266	-140,572
Annual Cost $/kl Yield	-$3.50	-$4.84	-$6.35
Levelised cost$/KL	-$3.31	-$4.48	-$5.74

Late idea: reduce costs of tanks by replacing with inground storage – save approx $500k and reduce levelised costs down to $1.50/kL

Life cycle costs

Life cycle costing	000’
Capital expenditure	**6,913**
Less cost of treatment including land	**900**
Net Capital expenditure	**6,013**
Operating expenditure	**444**
Payback	13.6 years
Revenue from 80 tonnes of production	**880**
Net present value - 4% discount	**1,535**
Internal Rate of Return	**6.0%**

Embodied Energy	**600 tonnes of CO2**
Reduced food miles	27 tonnes/annum
22 years to become carbon neutral	

conclusions

- System proposed can produce 80 tonnes of food locally
- It can reduce runoff frequency from 150 down to 25 days/yr
- Will save 22 ML/yr – keeps the H_20 in Tasmania or the MDB
- Could supply directly into the distribution network for unbeatable freshness
- Sensitive to wholesale price – 10%++ ROI possible in near future
- Cost same to buy 2Ha land & irrigate - however not always possible and critically sterilises land.
- With research & optimisation concept has potential to return 10%
- Rather than being a perpetual drain on taxpayers this concept demonstrates it is possible to create economically viable productive urban landscapes!

Thank you for listening!